Title: Airborne Coherent Continuous Wave CO_2 Doppler Lidars for Aerosol Backscatter Measurement

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Two focused coherent, continuous wave (CW) lidars have been developed by the Marshall Space Flight Center (MSFC) for airborne and ground-based measurement of aerosol backscatter coefficients. The first of these instruments uses a mixture of CO_2 and other gases, and measures backscatter at 10.6 m. The second lidar uses an isotope of carbon dioxide, which enables lasing at 9.1 m. The 10.6 m backscatter measurement serves as a reference to allow variations in backscatter due to aerosol concentration to be distinguished from variations due to spectral variability. The 10.6 m lidar has been used in airborne field programs since 1981. Development of the 9.1 m lidar was completed in early 1989. Recently, both lidars were flown on the NASA/Ames Research Center DC-8 research aircraft in the remote Pacific Basin as part of the NASA GLObal Backscatter Experiment (GLOBE) survey missions (GLOBE I, November 1989; GLOBE II, May-June 1990). The GLOBE program, of which the survey missions are the centerpieces, supports design and simulation studies for NASA's prospective Laser Atmospheric Wind Sounder (LAWS). LAWS is under development by the Marshall Space Flight Center (MSFC) as a facility instrument for the Earth Observing System (EOS), NASA's earth system science initiative. The 9.1 m lidar operates on the wavelength proposed for LAWS. Results from the GLOBE program are also applicable to other satellite-borne, lidar-based sensors that rely upon aerosols as scattering targets.

During airborne operation, the lidars are directed through separate germanium optical ports in the side of the aircraft. The transmit/receive axis is oriented a few degrees off normal to produce a Doppler shifted return signal that is distinct from the strong, non-shifted reference signal from the laser. The focal distance for both lidars can be varied. During GLOBE I, focal distances of approximately 10 m were used. For GLOBE II, focal distances of approximately 50 m were employed for improved sensitivity. The output signal from each lidar detector is processed by a Surface Acoustic Wave (SAW) spectrum analyzer/spectrum integrator. This processor provides the full spectrum of the lidar output signal, allowing the signal-to-noise ratio (SNR) of the Doppler-shifted signal to be estimated. During real-time and post-flight data analysis, a multi-stage signal processing algorithm is used (Rothermel *et al.*, 1990ab), which is based on the theoretical formulation by Vaughan *et al.* (1989). Calibration of signal processing is accomplished using a rotating diffuse target in the laboratory. Additionally, direct measurement of SNR is made from a manually-tuned spectrum analyzer to give backscatter estimates for checking instrument performance during missions.

For the second and most recent GLOBE survey mission, a developmental signal processing/data recording system was implemented. This system consists of a 6.5 MHz anti-aliasing low-pass filter, a 13.3 MHz sample rate analog-to-digital converter (ADC) and a digital signal processing (DSP) integrated circuit board. These system components are installed in a 80386-class, industry standard architecture personal computer. In operation, a time segment of the lidar detector output (containing the lidar return signal) is digitized by the ADC board, then transferred to the DSP board, where the lidar signal spectrum is calculated using discrete Fourier transform (DFT) algorithms. The resulting spectrum is integrated with previous spectra, in a fashion analogous to the SAW processor. After a number of spectra have been integrated, the data are transferred to the personal computer for display and real-time estimation of the SNR and backscatter using an identical signal processing algorithm. The "raw" spectra are recorded on write-once, read-many (WORM) optical disc for post-flight analysis, as well. In addition, the recorded data include universal time, aircraft and meteorological parameters, and operator comments. Several different types of displays of the data are used to assess instrument performance and atmospheric backscatter in real time.

During the GLOBE survey missions, transit flights were made from various waypoints between California and Tokyo, Japan and between the Arctic and Antarctic Circles. Standard flight altitude was typically 8-9 km; deviations for cloud avoidance were typically below 13 km altitude. The aerosol backscatter was found to vary with altitude, geographic location, and aerosol size and chemical composition (as determined by accompanying instrumentation). Backscatter values from optically clear air were found to vary over as much as five orders of magnitude. Examples of horizontal and vertical profile measurements will be shown.

References

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